ISLANDS IN THE NILE

A Geoarchaeological Approach to Settlement Location in the Egyptian Nile Valley and the Case of Karnak

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INTRODUCTION

The 'Cities and Urbanism in Ancient Egypt' conference was a celebration of forty years' work at Tell el-Dab^{c}a and the huge contribution Manfred Bietak and the project has made to our understanding not only of urban archaeology but also its place within the wider landscape. This paper aims to make a contribution to understanding the latter of these two areas by looking at the geomorphological origins of the site of Karnak as an island and the wider implications of island settings in the Nile Valley to further our understanding of settlement location between the First Cataract and Giza.

One of the main aims of our initial season at North Karnak in 2002 was to investigate Jean Jacquet's (1983, 96; 1987, 107) hypothesis that a watercourse existed just north of the Treasury of Thutmose I. Further fieldwork at Karnak in 2004 and 2005 provided the opportunity to extend our research to the Amun-Re complex. The aims of this work were to investigate the hypothesis that the footprint of the complex of temples expanded during the New Kingdom onto new land formed to the west of the area of earliest foundation as the river migrated westwards. The fieldwork also sought to explore the suggestion that Karnak may have been an island in the past (Egli 1959, 40–43).

CHARACTERISTICS OF THE NILE

Firstly, I will look at the geomorphological characteristics of the River Nile including the issue of its planform over the last 5000 years; the processes of migration and island formation and morphology in the Nile Valley. These characteristics and attributes of the river are essential to the interpretation of past land- and waterscapes in and around Karnak and the Nile Valley in general.

Channel Sinuosity and Braiding

Karl Butzer (1976, 34) has suggested that the river may have been more sinuous in the past than it is now. Based upon maps, Butzer (1976, 34) argues that the sinuosity has reduced from 1.33 in 1800 to 1.25 in 1935 and that the 'straightening' of the Nile may be due to a decline in Nile volume and the reduction of sediment discharge. Catherine (Katy) Lutley (2007) also notes a decrease in sinuosity from 1899 to 2005 in the As-Saff to Cairo stretch of the river.

Braiding occurs where the river accumulates sediment in the form of islands or bars such that the thalweg is dissected. This is caused not only by emergent bars and islands, but by underwater forms as well (Kiss and Sipos 2007, 210; Rapp and Hill 2006, 68–69). If the bars form mid-channel or a lateral bar is isolated from the channel bank by a flood, then the channel may split into two or more channels and form a braided pattern (Brown 1997, 63). Lutley (2007) suggests that the Nile may have been more braided in the past due to higher discharges of water and sediment and consequently there may have been many more bars and islands.

Flume tests and studies of a number of other rivers show that an increase in discharge leads to an increase in sinuosity to a certain point. Further increase in discharge causes a decrease in sinuosity and an increase in braiding. Other factors such as valley slope and grain size of sediment load also have a bearing upon the planform (see Fig. 1) (Bridge 2003, 154–155, 171–172, fig. 5.9; Leopold and Wolman 1957, 60). Sediment discharge has been reduced to almost zero since the construction of the Aswan High Dam in 1964 (Woodward *et al.* 2008, table 13.7). Thus a decrease in water and sediment discharge since the impoundment of the river may well have led to a decrease in sinuosity over recent decades in the stretches of the Nile studied by Butzer and Lutley. Channel-forming discharge (i.e. annual floods) in the Nile has varied over the last five millennia (Butzer 1984a; 1997a; 1997b; Popper 1951; Said 1993; Seidlmayer 2001; Woodward *et al.*, 2008, fig. 13.9) and the model of discharge and river planform suggests that the Nile has most likely been both more sinuous and more braided during the Pharaonic Period than it is today.

The other essential aspect to recognise is that channel patterns look different at different flow stages and that channel geometry changes through time (Bridge 2003, 147; Kellerhals *et al.* 1976, 822). Channel patterns are dynamic in both space and time (Brown 1997, 63, 67). Channels and bars generally exist for longer than a seasonal flood and will have experienced a complex history of depositional and

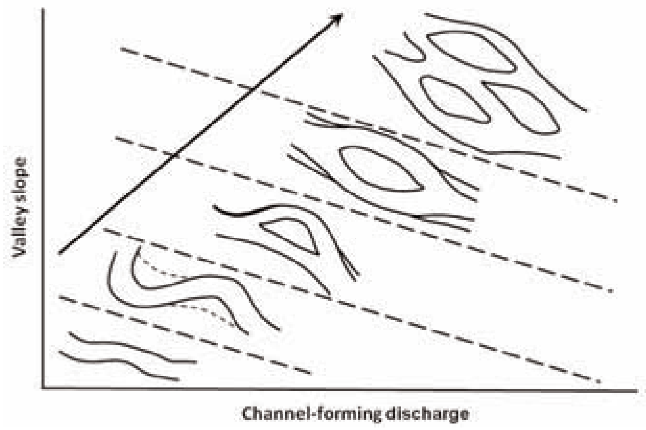

Fig. 1 Gradual variation of channel patterns with channel-forming water discharge, valley slope and sediment size. The arrow shows that width/depth and braiding increase with an increase in discharge and valley slope and that sinuosity increases, then decreases. The dashed lines show arbitrary boundaries between channel patterns that vary with sediment size (after Bridge 2003, fig. 5.9)

erosional modification over a range of flow stages. Whilst the overall form of the channel and bars is controlled by high-flow patterns, some features such as some cross-bar channels are formed during falling flow stages (see Figures 4, 8 and 13b) (Bridge 2003, 147). At lower flow stages many more mid-channel bars would have been exposed and thus a greater degree of braiding would have existed as can be seen in the sandy bed reaches of the Tana River (Collinson 1970, figs. 3, 5, 7; 1986, 25 fig. 3.7).

The Nile: a sandy bedform river

Another method of understanding rivers is by grain size. An easily diagnosed feature is the grain size of the bedload forming the bars and bedforms of the channel floor (Collinson 1996, 42). It is clear from numerous boreholes drilled throughout the Nile valley that the Holocene river (delta Neonile) has a sandy bedload (Attia 1954; Fourtau 1915). This is an important characteristic of the river and by analogy with other sandy bedform rivers we are able to understand further attributes of the Nile.

In general, accumulations of fine sediment in sandy bedload rivers is seldom thick enough to resist erosion and channel migration significantly (Collinson 1996, 45). The highly erodible banks lead to high width/depth ratios and to lateral movement both of the whole channel tract and of islands and bars within the tract. The Nile has exhibited a high width/depth ratio before and after its impoundment by the dams at Aswan (Butzer 1976, 16; Willcocks and Craig 1913, 233 table 131, 293).

Migration rates in various stretches of the Nile Valley have been calculated to range from 2 to 9 km per 1000 years (Hillier *et al.* 2007, 1013; Jeffreys and Tavares 1994, 158; Lutley 2007; Lutley and Bunbury 2008, 3). The 'Classic Point Bar Model' describes how migration of a meandering alluvial channel occurs through the erosion of the outer concave bank of a bend and the deposition on the inner convex bank (see Figure 4). The channel as a whole migrates laterally and the bend migrates downstream (Collinson 1986, 36; Waters 1992, 130). The higher migration rates are thought to include the shifts or 'jumps' of the river around islands as the minor channel silts up (Lutley 2007; Lutley and Bunbury, 2008, 3). A good example of this is the formation and subsequent attachment of Gezirat Bedrashein to the floodplain documented by the EES Survey of Memphis (Jeffreys 1985, 51; 1996, 292; Jeffreys and Bunbury 2005, 10–11).

Anthropogenic activity including dumping and armouring of the riverbank will have an impact upon migration rates (Jones 1997, 106). Large settlement sites such as Karnak may also restrict migration of the river producing a narrower meander belt than the river would otherwise have (Hillier *et al.*, 2007, 1014). The Late Period retaining wall west of the First Pylon at Karnak, currently under investigation by a Supreme Council of Antiquities team led by Mr Mansour Boraik, may well have been built to prevent an eastward migrating river from eroding the site away. Clarke's (1924) 'breakwater' wall at El-Kab appears to have served the same function.

Hierarchies of repetitive bedforms, ripples and dunes are the dominant features of sandy bedload rivers. Falling discharge within such a system also leads to the partial emergence of the riverbed. The high areas that emerge first split the flow at a variety of scales from large compound bars to individual bedforms and modification occurs due to the change of flow paths of the river (Collinson 1996, 45). The largest morphological features of sandy bed streams are sand bars or sand flats (macroforms). They occur in both marginal and mid-channel positions and have been called 'side, lateral or alternate bars' and 'mid-channel or braid bars' respectively amongst other names (Bridge 2003, 141, 145; Collinson 1986, 27; Smith 1978). They are built up from the accretion of smaller mesoforms e.g. dunes. The nucleus of the sand flat may come from the emergence of a sector of a cross-channel bar. Erosion from one bank and local scour of the bed are deposited in the 'crossover' zone where flow diverges as the main current (thalweg) moves from one bank to another (Ashmore 1982, 327; Church and Jones 1982, 302–303; Hooke 1986, 842).

Fig. 2 A mid-channel (braid) island (150 m at its widest, 1100 m long) lying west of the village of Kuddaya, 12.5 km south of el-Lisht village. River flows from bottom to top of image (Image © Google Earth)

Once the sand bar has developed it may persist for a considerable time and grow by vertical accretion of fine-grained sediment from suspension. Baffling effects caused by any vegetation aid deposition and add to its stability (Carey 1969, 986; Collinson, 1986, 27; 1996, 47; Hooke 1986, 845; Kiss and Sipos 2007, 219; Leopold and Wolman 1957, 44). With the lateral migration of the main curved channel, the island also expands laterally as well as extending downstream. Islands may also accrete upstream (see Fig. 6) (Bridge *et al.* 1986, 856). The channels on both sides of an island may co-exist for decades. However, in some bends the minor (chute) channel may be sealed off as the bend migration progresses and thus a slough is formed (Bridge *et al.* 1986, 856–857). The slough fills in with silt and clay deposits and the island becomes attached to the floodplain. Augering in the former minor channel at Gezirat Bedrashein suggests that this can be a rapid process taking only tens of years (Jeffreys and Bunbury 2005, 10–11).

Islands in the Nile

Whilst the discharge and sediment transport may have changed since the imposition of the dams at Aswan and barrages along the river (Woodward *et al.* 2008), study of maps, photographs and paintings prior to impoundment of the Nile, as well as comparison with other sandy bedform streams, suggest

Fig. 3 View of the large island of Jazirat ash-Shuraniyyah east of el-Marâgha, c. 18 km north of Sohag. The island is c. 2.3 km across at its widest point and c. 5 km long. River flows from right to left of image. The Egyptian General Survey Authority (1991, sheet NG36 J4a Suhaj) map reveals that the spot height at the centre of the island of 59 m a.s.l. is the same height as the surrounding floodplain (photo. A. Graham, taken from commercial aeroplane 2006)

that many of the features found in the Nile today appear likely to have been found at other times in the Holocene.

Islands in the Nile come in many shapes and sizes. Perhaps the 'regular' shapes that might spring to mind are the 'long thin' (low width to length ratio) and 'short fat' (high width to length ratio) islands found for example west of the village of Kuddaya (Fig. 2) with a length to width ratio of 7.3:1 and Gezirat ash-Shuraniyyah (Fig. 3) with a length to width ratio of 2.2:1 respectively. Length of islands can range from a few tens of metres to several kilometres as in the case of Gezirat ash-Shuraniyyah at c. 5 km. However, other 'irregular' island formations can be found in the Nile today and in the past.

Bars with limbs or 'horns'

A distinctive type of compound bar found in the Nile today is that with downstream elongated limbs or 'horns', for example near al-Zaniyah (3 km north of Karnak) (Fig. 4) and Edfu (Figs. 5 and 6). RICHARD LEPSIUS appears to have observed and recorded such an island near Beni Hassan in the 1840s prior to the imposition of barrages and dams (Fig. 7) (LEPSIUS 1849, Bl. 61). Sandy bedform flume experiments have also recorded bars with elongated limbs (LEOPOLD and WOLMAN 1957, fig. 34). These compound bars are a notable feature of other sandy bed rivers such as the South Saskatchewan (BEST *et al.* 2006, 249–250, fig. 8; CANT and WALKER 1978, 635–636, figs. 5, 9–11; SAMBROOK SMITH *et al.* 2006, 419, fig. 6), the Calamus (BRIDGE *et al.* 1998, 985 fig. 8) and the Jamuna (Brahmaputra) (ASHWORTH *et al.* 2000, 543 fig. 8b). The South Saskatchewan is an interesting and important parallel to the Nile as it was dammed in 1967 and study of the river before and after this reveal that the scale and type of sandbars has not changed (CANT and WALKER 1978, 627).

These bar formations appear to form from two to four unit bars, where one unit bar forms the central core, the bar head. This then promotes accretion from additional unit bars on either side leading to the formation of the distinctive limbs. They can develop either a symmetric or asymmetric morphology. Flow and sediment transport asymmetry in the river leads to one limb becoming longer than the other (CANT and WALKER, 1978, 636; SAMBROOK SMITH *et al.*, 2006, 419).

Fig. 4 A close-up of an island west of al-Zaniyah, c. 3 km south of Karnak. The island originated as an upstream bar head with bars attached to either side of it as limbs or 'horns'. The downstream end and the slack water area behind the main bar have now started to infill and form new land. Note the new land, point bar, accreting on the inside of the bend. River flows from bottom to top of image (photo A. Graham 2004)

Fig. 5 An island with limbs immediately upstream of the Edfu bridge. The image is looking SSW and the river flows from top to bottom of the picture. Note the crest of the bar on the east limb is closest to the river. Its formation is similar to that of levees on the riverbank (photo A. Graham 2007)

Fig. 6 The satellite image clearly shows the limbs of the island stretching downstream. It also shows upstream accretion of the island from the bar head (Image © Google Earth)

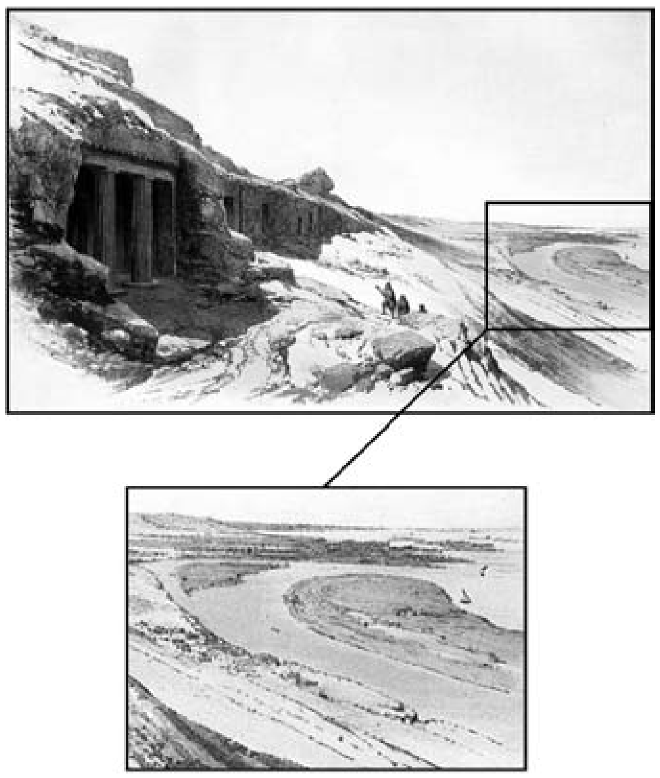

Fig. 7 This view of the Beni Hassan necropolis looking upstream records an island in the river (inset and enlarged) that has a low lying area under water within it and a higher west (right) flank suggesting an asymmetric flow (after Lepsius 1849a, Bl. 61)

The examples cited in the Nile show different stages of development. The island at Edfu shows an elongation of the bar limbs as well as upstream accretion of the bar head. The al-Zaniyah island shows further downstream accretion to the point where the two limbs have almost joined at the bar tail end. Cross-bar (or chute) channels can also be seen cutting through the limbs of this island (cf. Best *et al.* 2006, fig. 8b; Bridge 2003, 145 fig. 5.1 (m)). The island near Beni Hassan appears to show an advanced stage where the bar head and flanks are well developed, but have left a water filled depression within the island. The far, western, flank of the island appears higher in the painting than the near side of the island suggesting that the island developed in an asymmetric manner (Fig. 7).

The limbs or horns of such islands are similar to river levees in that they are higher than the rest of the island due to greater deposition of sediment than the low-lying area behind the bar head (for cross-sections see Bridge 2003, fig. 5.16). The location of earliest occupation on such an island would be on the bar head and the limbs. The higher part of less complex bar forms that expand laterally and vertically to emerge as an island, such as the one near Kuddaya (Fig. 2), are more likely to be at the centre of the island. Thus the earliest occupation may have been located at the heart of the island.

Bodies of water within emergent and stable islands

Many emergent islands in the Nile have water filled depressions within them, which may be connected to the river. An island c. 1 km downstream of el-Lisht has an almost land-locked body of water within it measuring c. 95 × 165 m (1.6 ha) (Fig. 8). Further downstream the emergent islands near Ghammaza as-Sughra appear from satellite imagery to be a series of compound bars, parts of which have emerged through the vertical and lateral accretion with the growth of vegetation increasing deposition through baffling. These emergent islands are characterised by a number of areas remaining submerged. The eastern island has a notable large body of water accessible from the river near the tail end (Fig. 9). Further study is needed to clarify the history of such islands.

Movement of the Nile in the Theban region

Maps, paintings, aerial photographs and satellite images have been used to record changes in the course of the Nile in the Theban region since the work of Napoleon's geographers and engineers in the late 1790s (Bunbury *et al.* 2008; Graham and Bunbury 2005, 19; Hillier *et al.*, 2007). They include shifts in the Nile due to point bar formation and through the formation of islands and their subsequent attachment to the floodplain and the switching of the main channel of the river from one side of an island to the other. Islands have also joined through depositional processes to form larger islands as has been observed west of Karnak during the 19th century CE (Bunbury *et al.* 2008).

The river has been moving eastwards over the last two hundred years in the area of Karnak until the imposition of stone and concrete armouring of the east bank of Luxor (Egyptian General Survey Authority 1991, Al-Uqsur (Luxor) sheet NG 36 F6a; Engelbach and Macaldin 1938, 52; Jacotin 1821, pl. 5; Lepsius, 1849, taf. 7). The process described above where the minor channel silts up and an island is joined to the floodplain is clearly seen in the example of 'Banana Island' c. 3 km upstream of Luxor (Bunbury *et al.*, 2008, figs. 4a, 4b; Department of Survey and Mines 1943, 'Luxor' portions of sheets 33/765 and 33/780; Egyptian General Survey Authority 1991, Al-Uqsur (Luxor) sheet NG 36 F6a). Immediately upstream of 'Banana Island' the same natural process is starting to take place in the minor channel of 'Crocodile' Island

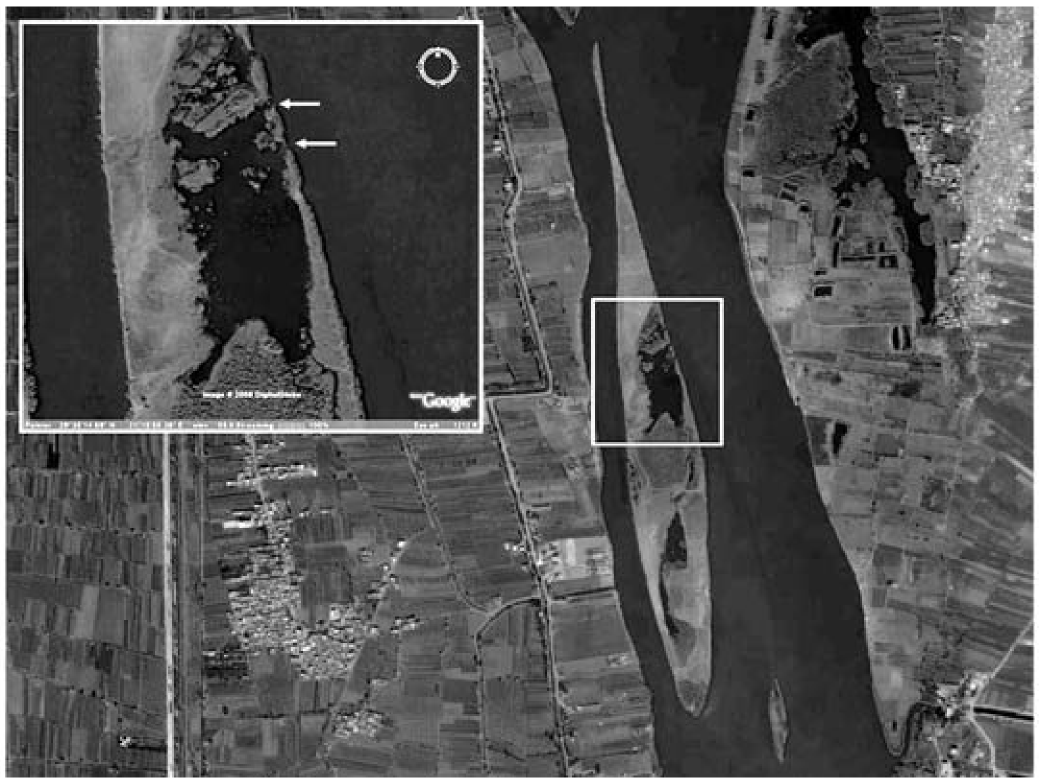

Fig. 8 Satellite image shows the location of island c. 1 km downstream of el-Lisht. The channel to the west of the island is 60–120 m wide, the island is 210 m at its widest and 1900 m long including a downstream tip that is 300 m long, but only 6–18 m wide. The close-up of the island (top left) shows a body of still water. The white arrows mark cross-bar channels, 3-5 m wide, connecting the water with the river (Images © Google Earth)

Fig. 9 Satellite image shows two emergent islands west of Ghammaza as-Sughra, c. 10.5 km downstream of el-Lisht. Numerous bodies of still water can be seen within these emergent islands, one of which is 30–60 m wide and over 250 m long (1.68 ha) and connected to the river at the downstream end. The mouth of this backwater is c. 63 m wide (marked by the white arrow). The river flows from bottom to top of the image (Image background © Google Earth)

Fig. 10a This photo taken by A. Beato some time before 1872 shows the waterway, Khor el-Ammari, rejoining the Nile to the south of the Temple of Luxor (Image no. 3456, reproduced with permission of the Griffith Institute, University of Oxford)

Fig. 10b This unsigned photo taken facing south from the Temple of Luxor some time before 1872 shows the waterway, Khor el-Ammari, rejoining the Nile (Image no. 3460, reproduced with permission of the Griffith Institute, University of Oxford)

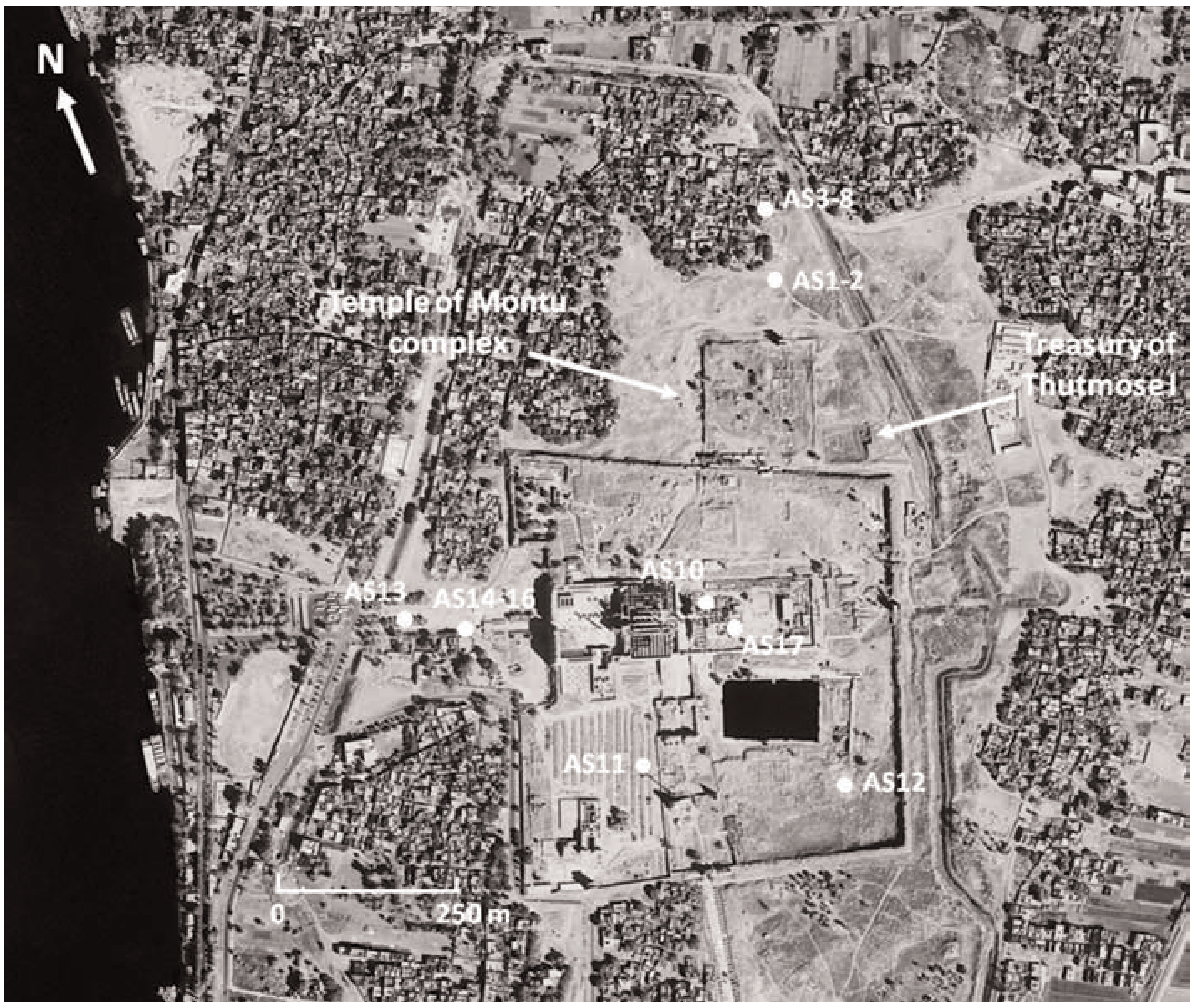

Fig. 11 Location of the auger sites (AS) carried out at Karnak from 2002-05 (background, image no. 69556 © CFEETK)

(Jazirat al-Bayadiyyah on the E.G.S.A. maps (1991, Al-Uqsur (Luxor) sheet NG 36 F6a; 1999).

Between 'Banana Island' and Luxor Temple, the former island Gezirat el-'Auwâmiya (Jazirat-al-'Awamiyyah) has also become attached to the east bank of the river. The *Description de L'Égypte* map (Jacotin, 1821, pl. 5) shows an island immediately south of Luxor temple with its minor eastern channel passing just south of the rear of temple. David Roberts recorded this channel in his 1838 painting of Luxor temple from the southeast (Roberts 1846, pl. 15). Photos taken prior to 1872 also clearly show this minor channel south of Luxor temple (see Figs. 10a, 10b). However, by the 1940s the 1:25000 map shows this minor channel, recorded as the Khor el-Ammari, in-filled at the downstream end (Department of Survey and Mines 1943, 'Luxor' portions of sheets 33/765 and 33/780). This may well be the result of anthropogenic activity given that the Winter Palace Hotel was constructed in 1886.

The temples of Karnak

The programme of augering between 2002 and 2005 (see Fig. 11) carried out by the Karnak Land- and Waterscapes Study (KLaWS) has revealed that the first temple was founded on an island and that the river then migrated westwards and northwards producing new land upon which the Egyptians were able to expand in the Middle Kingdom and New Kingdom (Bunbury *et al.* 2008; Graham and Bunbury 2005).

Using the understanding of island formation and morphology in the Nile, I would like to revisit some of the sedimentary evidence from Karnak in an attempt to interpret further the nature of the emerging island of Karnak and the earliest occupation of the site.

Northern limit of the early island

Augering approximately midway between the Temple of Montu enclosure and the tribune at North Karnak (AS02) retrieved ceramic fragments throughout the 10.95 m of augering. This finding resonates with the augering carried out between the Amun-Re and Mut complexes in the 1960s (see the discussion below). The most important section of the auger is the bottom 2 m. Black (7.5YR 2.5/1) anoxic fine sand recorded at the bottom of the auger (65.84 m) with reddish black (2.5YR 2.5/1) mud (the reddening being due to degraded ceramic fragments) immediately above reveals a still water environment with rootlets being found in the core above. Above this are a series of thin fining upwards sequences of sands and silts up to c. 67.70 m a.s.l. which included mud laminations at the top of one sequence (at 66.80 m a.s.l.). Such fining-upwards sequences are observed in the lateral migration of a channel due to the decrease in flow power on the inner curve of a bend (READING 1986, 6). Rootlets observed in the top/base of each fining-upwards sequence indicate plant growth prior to the next depositional event. At 67.40 m a.s.l. an estimated 70% of the total weight of the retrieved material is made up of rotted ceramic fragments. Above this, ceramics are estimated at >15% by weight to 68 m a.s.l. This high proportion of ceramic fragments suggests that dumping took place down the riverbank.

Although there appears to be some contamination of the ceramic assemblage with Marl A5 sherds present, the other datable fragments in the dumping event(s) are within a Middle Kingdom to Second Intermediate Period range. The channel migration deposits below this fit in the same date range with one sherd dated to the early 18th Dynasty. This data appears to confirm Jean Jacquet's hypothesis that there was a channel north of the Treasury of Thutmose I and that the northern limit of Karnak lay somewhere between the Treasury and AS02 when the first temple was established (BUNBURY *et al.* 2008; GRAHAM and BUNBURY 2004; 2005).

Southern limit of the early island

The southern limit of the Amun-Re island in the Middle Kingdom appears to be somewhere between the 10th pylon and the Temple of Mut enclosure. Corings carried out in the 1960s under the direction of JEAN LAUFFRAY (1968, 338–339) suggest that 'virgin' or artefact free ground was reached on average 6 m below the Ramesside level in the enclosures of the Amun-Re and Mut complexes. Between these two complexes sherd-bearing sediments were found 12 m below the surface of the dromos. LAUFFRAY (1968, 339) interprets this as an area of low lying land between two "éminences naturelles". These 'natural hills' are in fact islands formed in the river and the low-lying land would have been a minor channel in the Nile between the two islands. The silting up of this channel must have occurred prior to the construction of the processional way built by Tutankhamun, which ceremonially linked the two complexes (CABROL 2001, 24, 224).

Wetland environment between the 9th pylon and the sacred lake

Augering between the 9th pylon and the sacred lake in 1967 encountered a layer of 'vase noire' at a level below that of the bottom of the sacred lake (LAUFFRAY 1968, 339). LAUFFRAY (1968, 339) believes that this indicates that a marshy zone greater than the current sacred lake existed before it was defined by the construction of the stone embankments. We have seen from the discussion of island formations in the Nile that a natural body of still water within an island setting is far from unusual (see Figs. 4–9). The lack of detail in Lauffray's report means that it remains unclear how extensive this wetland area was and at what date it became filled in and built upon. It seems highly plausible that this low-lying wetland area was filled in during the expansion of the temple. Further work in this area of Karnak will help clarify this picture.

West bank of the island at Karnak

The idea that the bank of the river was much further east than it is today was first proposed over a century ago (LEGRAIN 1906a, 112; 1906b, 141). Georges Legrain's excavations in the area of the cachette in the first court between the southern end of the 3rd pylon and the 7th pylon led him to believe that this area had once been a marsh or river bank. LEGRAIN (1906a, 112; 1906b, 141) describes finding strata of clay, sand, clay up to 6 m below the surface which had a slight slope downwards from east to west. An excavation in front of the northern face of 8th pylon revealed similar stratigraphy.

The augering at AS10 (BUNBURY *et al.* 2008) together with the excavations of EMMANUEL LANOË and OPHÉLIE DE PERETTI (2004) in the north court between the 5th and 6th pylons and the 2006 excavations of ROMAIN MENSAN (in preparation) below the chapels of Thutmose III east of the 6th pylon confirm Legrain's hypothesis.

Fig. 12 The main image shows the downstream apex of Jazirat al-Bujah c. 12 km downstream of Sohag. Inset is a close-up of a small island with an embayment on its western side approximately 30 m by 15 m at its longest and widest points (photo A. Graham, taken from commercial aeroplane 2006)

AS11, located in a narrow cleared area between the west wall bounding the court between the 8th and 9th pylons and the higher ground level between the temple of Khonsu and the main Amun-Re temple, provides us with interesting evidence of an area of still water in the Middle Kingdom and also differing dumping events.

Within the ceramic assemblage from the cores of AS11 two distinct phases were detected: the upper section from 74.19 m to 70.08 m a.s.l. contained material ranging in date from the Middle Kingdom to the Roman Period, including one piece of Late Ramesside Palestinian ware in core 16. Below this from 69.83 to 65.55 m a.s.l. Middle Kingdom material, predominantly from the 12th Dynasty, was found.

A column of greenish-black (Gley1 2.5/1 5GY-10Y) anoxic mud is found from c. 66.50 m down to the terminus of the auger at 65.55 m. This is significant because it indicates a still water environment. Anoxic mud can be recognised by its dark colour and high organic content and the smell of hydrogen sulphide (H_2S). Anoxic events are caused by the decomposition of organic matter by oxygen-utilising bacteria. These conditions can be found in a number of environments, for example, enclosed or semi-enclosed bodies of water such as such as silled basins, inland seas, lakes, small bays and fjords. Here water circulation is limited horizontally by the geomorphology. This may result in oxygen not being replenished to the bottom waters from the surface waters. Vertical circulation may be limited by a stable water column, which arises from a vertical density gradient, due to either temperature or salinity stratification (GOLDHABER 1978, 296–297; LEEDER 1982, 233). Hydrogen sulphide may also accumulate due to persistent waterlogging of soils in natural freshwater marsh / wetland environments due to the reduction of sulphate or sulphide by bacteria (CORFIELD 2007, 149, 151; DE GROOT and VAN WIJCK 1993, 84, 93; KOCH *et al.* 1990, 399–400; SIKORA and KEENEY 1983, 253).

In the context of the River Nile and floodplain two environmental scenarios seem possible. If AS11 is located along the line of the riverbank, it could possibly indicate an embayment linked to the river whereby suspended sediment (silt and clay) enters the basin area but where sand-sized sediment is excluded from the area. Natural embayments can be found on islands throughout the Nile Valley (Fig. 12) that could provide ideal mooring locations.

The second environment is that the greenish-black anoxic mud represents a wetland area within the island of Karnak and that the banks of the island mean that only mud is deposited in the area during the inundation. It may well be a partly enclosed lake environment that can be found within island formations in the Nile that we have already discussed (see Figs. 4–9).

The anoxic conditions suit the growth of hydrophytes (hydrophytic vegetation) (Lewis 2001, 93). Hydrophytes known from the Middle Kingdom include *Arundo donax*, the Italian reed or Spanish Reed, (Germer 1985, 203–205; Keimer 1984, 72) and *Phragmites australis,* the common reed (Egyptian, *isw*) also known as *P. communis* (Erman and Grapow 1926, 127, 21–22; Hepper 1990, 35). However, our studies to date have not identified floral species at Karnak. There is a clear absence of rhizoliths / rhizoconcretions in this anoxic mud. This might suggest that the water is too deep to host such hydrophytes.

It may be that our findings accord with the layer of 'vase noire' described by Lauffray (1968, 339) and thus extend the area of marsh / wetland as far west as AS11. However, without any detail in their report caution is prudent. There is no mention of sherds or rhizoliths being found in the 1967 augering or the date of this marshy environment.

In AS11 between 65.92 and 65.56 m a.s.l. the anoxic mud was made up of >25% granule and pebble-sized clasts by weight. These clasts included sandstone, limestone, granite, bone and charcoal with sherds making up 60% of the total population. This non-sediment component suggests dumping into the still water environment during the Middle Kingdom. Dumping appears to have continued in the Middle Kingdom. Above the marsh environment up to 69.83 m a.s.l. we found Middle Kingdom material, predominantly from the 12th Dynasty, in poorly sorted sediments. The poor sorting is indicative of anthropogenically deposited material (Rapp and Hill, 2006, 51). Above this the ceramic fragments were chronologically heterogeneous, ranging in date from the Middle Kingdom to the Roman Period but the sediment remained poorly to very poorly sorted suggesting dumping continued to the present-day ground level.

These anthropogenic deposition or dumping events are different. The dumping into the anoxic environment is discarded artefacts only and perhaps represents the use of the low-lying area as an open 'landfill' site by the occupants of Karnak. The deposition above the black mud facies includes sediment as well as discarded artefacts. Does the Middle Kingdom deposition directly above the marsh environment represent organised in-filling of the area? Further augering in the area of AS11 is necessary to clarify the precise nature and extent of this 12th Dynasty environment.

Middle Kingdom court environment

Auger Site 17 was carried out in CFEETK excavations in the Middle Kingdom Court in 2004. Ceramic fragments retrieved from the uppermost 55 cm (72.84 to 72.29m) are chronologically heterogeneous ranging from the Second Intermediate Period to the Roman Period suggesting that they are disturbed levels. Below 71.89 m the sediment is artefact free. From 69.69 to 69.16 m a.s.l. there are two thin fining-upward sequences of very well sorted coarse to fine grained sand (phi 1 to 2), dark greyish brown to brown in colour. These deposits appear to represent the formation of the sandbar upon which the first temple was founded. The sediment above this includes numerous rhizocretions and burrows in very well sorted muds with organic remains. This appears to represent further deposition on to the sand bar to the extent that it becomes an emergent island where vegetation begins to grow.

East bank of the island

Auger Site 12 is located on the edge of a deep sondage excavated by Marie Millet (Millet 2007) to the south-east of the sacred lake. A series of fining upwards coarse to fine grained sand packages between 69.24 and 68.10 m a.s.l. are indicative of the growth of a sandbar. Above this up to 72.29 m intercalated sands and silts along with roots, mica and rhizoliths indicate a sandbar that has emerged from the river and become vegetated such that it baffles out larger particles from the water such as the mica (Bunbury *et al.* 2008).

To the east of Karnak augering and trench work as part of the Luxor Wastewater Project recorded black silts in the village of El Nag^{c} el-Fuqani (Edwin Brock pers. comm) which may represent the in-filling of a former river channel. This appears to be consistent with the findings of Ismail *et al.* (2005) who identified a silty-clay geoelectric unit east of Karnak which they suggest represents a former channel. Future augering in this area would help clarify this interpretation and date the feature.

Early Occupation of Karnak

Much of the earliest, First Intermediate Period, occupation of Karnak lies in the area between the excavations of Millet and the Treasury of Thutmose I (Jacquet-Gordon 2007; Millet 2007, 697–698, pl. XXXIX). This fits well with our understanding of bar and island formation discussed and represents the area of highest ground along the east side of the island. A useful present day analogous bar is to be found just upstream of Luxor (see Figs. 13a, 13b). The west side of the early island lies in the area

Fig. 13a (above) and 13b (below) show a bar emerged from the river just south of Luxor now vegetated and used for grazing. It clearly shows that the bar is much higher than the inner part that slopes gently down to the wetland area to the west (left). In the foreground of image 13b we can see a cross-bar channel. NB the east (right) side of the island is steep due to slumping that was most likely caused by boat-generated wave erosion (see Nanson *et al.* 1994). The river is flowing from bottom to top of the photographs (photos A. Graham 2004)

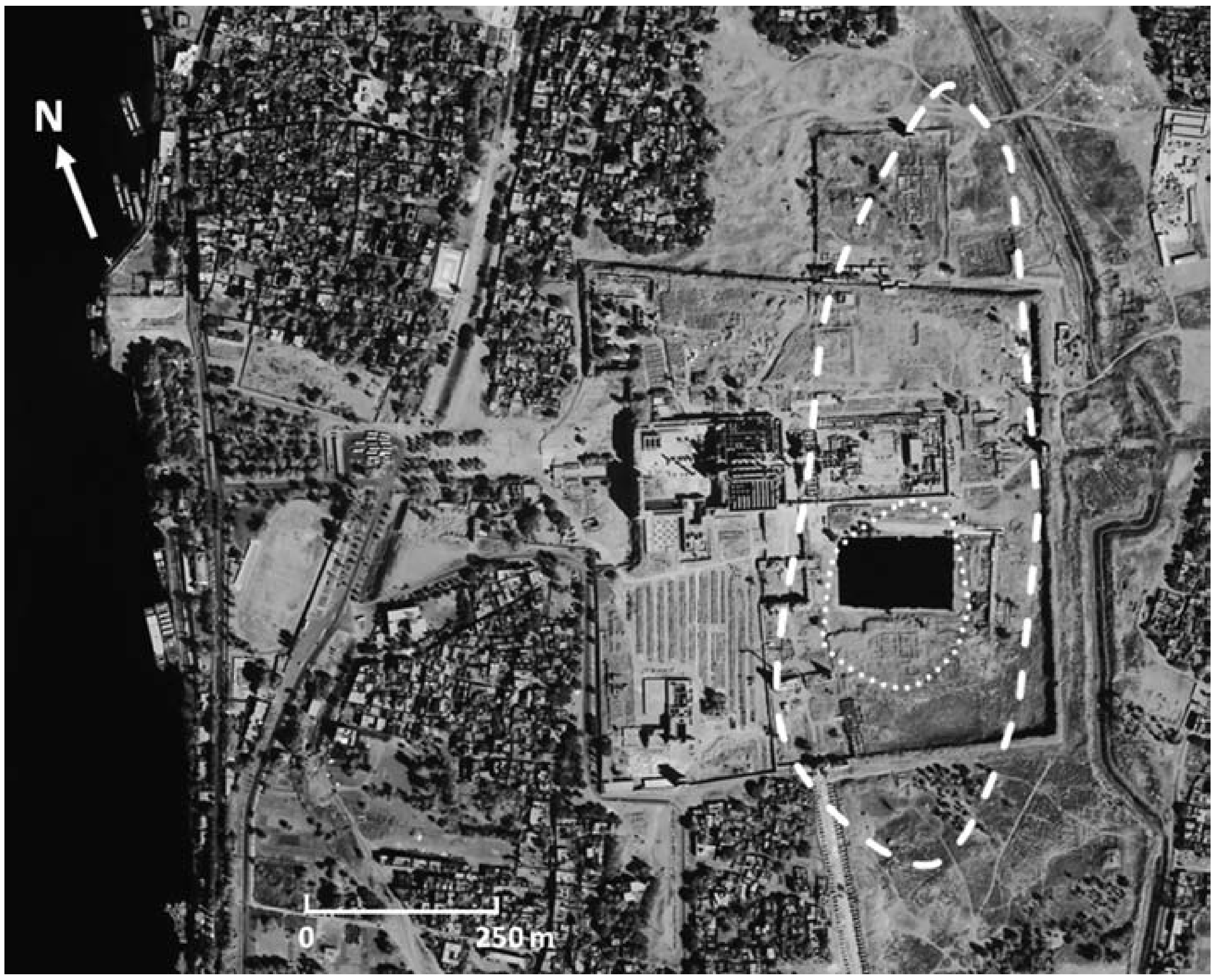

Fig. 14 Aerial view of Karnak showing suggested outline of 'Amun' island during the late 11^{th}–early 12^{th} Dynasty (dashed line). The dotted area within the island marks the suggested wetland / marsh area identified in 1967 (Aerial photo 69556 © CFEETK)

between the 10^{th} and 6^{th} pylon and the area appears to have been a low-lying wetland area that subsequently became in-filled over time both through natural and anthropogenic deposition. It is on this high ground that we find the bakery/brewery, storage facilities and living zone (MILLET 2007). The lower ground is the site of the monumental temple architecture, which we know was liable to flood from time to time (BAINES 1974; 1976; HABACHI 1974). Figure 14 shows the suggested geometry of the 'Amun' island and its wetland area during the first occupation. However, further research is required to establish the precise nature and geometry of this island.

LAUFFRAY (1968, 339) points out that a hill and marsh would evoke cosmological origins of the hill emerging from the watery chaos of Nun and suggests that this might in part explain the choice of the site for the construction of a sanctuary which was to become the residence of Amun.

SETTLEMENT LOCATION IN THE NILE VALLEY

BUTZER (1959; 1976; 1984b; 2001) maintains that levees (either active or abandoned) would have been the preferred settlement location in the convex Nile Valley floodplain. It should be noted that active levees on the erosional side of the river would not be a rational choice for a settlement, as the migrating river would threaten it. Extant levees found to the west of the 'Qamula-Danfiq' bend (between Luxor and Naqada) are between 250–500 m wide (DEPARTMENT OF SURVEY AND MINES 1943; HILLIER *et al.* 2007) and would have provided considerable space for ribbon settlement patterns (JEFFREYS and TAVARES 1994, 159).

Islands are excellent locations for settlement. Not only do 'hard rock' outcrops in the floodplain e.g. Elephantine and Edfu, which are not readily erodible by the river, provide locations important settlement and religious centres in the Egyptian Nile Valley, but so do alluvial islands as we have seen at Karnak and most probably at the town site of Nekhen too (Bunbury and Graham forthcoming). David Jeffreys (1985; 1996, 290, 292) has long recognised the importance of alluvial islands as a resource for agriculture and settlement extension. Alluvial islands grow laterally and in a downstream and even in an upstream direction. They may also in time become attached to the floodplain by silting up of the minor channel and are thus preserved as the Nile migrates across the valley. Maps reveal that islands are as high (see Fig. 3) if not higher than the surrounding floodplain, e.g. Armant Island (Egyptian General Survey Authority 1991, Al-Uqsur (Luxor) sheet NG 36 F6a). Their proximity to the river means that greater deposition of sediment occurs on them than the surrounding floodplain. Factors such as height, proximity to the river, preservation and expansion as well as cosmological considerations make them an ideal choice for occupation. Understanding islands as important locations for settlement brings with it a whole array of other interesting questions concerning access, transport, the waxing and waning of importance as the river migrates away and the island becomes attached to the floodplain.

Initially an emerging sandbar may be used as a place of cultivation with terms such as *m3wt* being used to refer to such 'new land' (Eyre 1994, 75–6). Perhaps they begin as places of seasonal occupation when the river is low. Vegetation may further the deposition on the emergent island until eventually it becomes suitable for more permanent occupation. Such decisions are presumably determined in part by an assessment of the risk of flooding (Seidlmayer 2001). A geomorphological approach to the many linguistic terms referring to land in the floodplain will no doubt further our understanding of agriculture practices.

The study of maps and satellite images using the methods of Hillier *et al.* (2007) and Lutley and Bunbury (2008) has enabled the identification of former river levees. Former island sites can be often be inferred by their location between former river levees. A primae facie look at Dieter Kessler's (1981, karte 1) map of ancient koms between Mallawi and Samalut reveals that many follow a ribbon pattern that we would associate with settlement on levees whilst other koms appear to lie between the levees and suggest island origins. Whilst a quantification of island and levee origins has not yet been achieved, further use of remote sensing techniques to identify previously unknown archaeological sites, such as those employed by Sarah Parcak (2005; 2006), and ground-truthing by augering (Bunbury *et al.* 2008; Bunbury and Graham, forthcoming) may enable us to build up a clearer picture at least on a regional scale. As we continue to debate and refine our understanding of discharge during particular periods such as the late Old Kingdom-First Intermediate Period (cf. for example Butzer 1997b; Hassan 1997; Krom *et al.* 2002; Moeller 2006; Seidlmayer 2000; 2001; Stanley *et al.* 2003; Woodward *et al.*, 2008), we will better comprehend the settlement location decisions in the Nile Valley.

It is the Nile that shapes the floodplain and provides suitable locations for settlement. The construction of walls and platforms were also necessary at times to resist the river (Szafranski 2003). Ultimately, it may have been migration of the Nile or high inundations that formed part of the decision to abandon settlements and establish new ones (Jeffreys 1996).

ADDENDUM

Since the conference in November 2006, the Karnak Water- and Landscapes Study has carried out two further seasons in 2007 and 2008. This work does not substantially alter the interpretation of the 'island of Amun-Re' presented here. Whilst short fieldwork entries have been made in *Egyptian Archaeology* 'Digging Diary' and *Orientalia*, this work will be published in full with colleagues in the near future. AS29 (2007) located between the 5th and 6th pylons supports the notion that the west bank of the island lay in this area during the late 11th–early 12th Dynasties. AS28 carried out east of the processional way and approximately halfway between the Amun-Re and Mut enclosures confirms Lauffray's hypothesis that there was a river channel between the two complexes during the Middle Kingdom. AS30 (2007) reveals that the Temple of Opet was founded on a sandbar and AS33 and an electrical resistivity tomography profile (2008) between the Temple of Khonsu and the court of the 10th pylon suggests that this was separated from the area of the 9th and 10th pylons of the Aumn-Re complex by an area of low-lying land and appears to confirm Legrain's (1906a; 1906b) hypothesis that the Temples of Opet and Khonsu were established on a separate island.

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